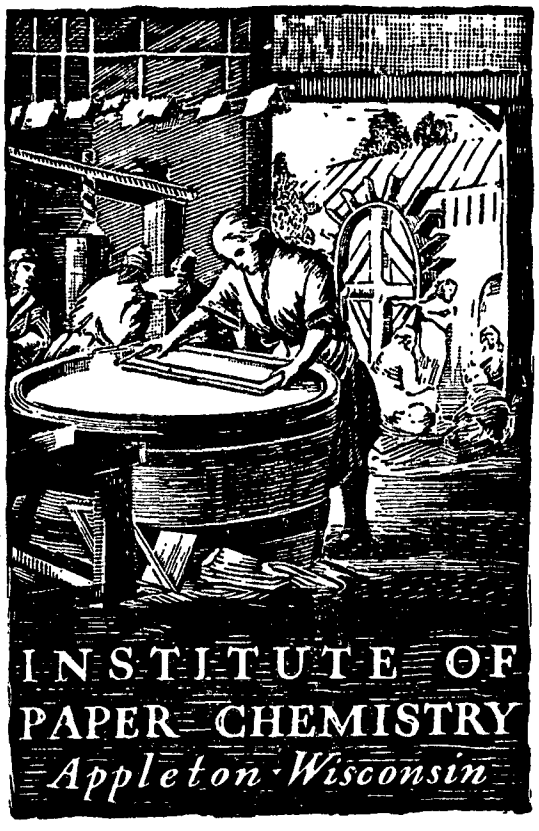

A COMPARISON OF VARIOUS METHODS OF ADDING PRESERVATIVES AND THEIR INFLUENCE ON THE HOLDING CHARACTERISTICS OF ORANGES PACKED IN FIBERBOARD CASES

Project 1108-7-C

Progress Report One

to

FOURDRINIER KRAFT BOARD INSTITUTE, INC.

March 1, 1953

THE INSTITUTE OF PAPER CHEMISTRY

Appleton, Wisconsin

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SUMMARY

This study was initiated at The Institute of Paper Chemistry by the Fourdrinier Kraft Board Institute, Inc., for the purpose of comparatively evaluating the merits of various applications of Phenodor and diphenyl phthalate-wax applications in preventing spoilage of oranges packed in corrugated fiberboard boxes. In particular, this study was concerned with the comparative holding qualities of oranges packed in commercial Phenodor-treated orange cases and the method of adding the preservative as disclosed in U.S. patent 2,607,694 granted to A. J. Rinck August 19, 1952 entitled, "Method for preventing decay of citrus fruits, vegetables, etc." In brief, the above invention relates to the use of impregnated paper or paperboard, preferably of a size smaller than the maximum diameter of the individual fruit, which is distributed among the fruit when packed.

In order to determine the above, holding tests were made using California and Florida oranges which were packed in untreated corrugated boxes, with and without the impregnated particles, and commercial Phenodor boxes. In the holding tests made with diphenyl phthalate as the preservative the oranges were inspected weekly during a four-week period. In the holding tests in which Phenodor was used for impregnating the particles, as described in the Rinck patent, the oranges were inspected after the eighth, sixteenth, and twenty-first day. After each

inspection the spoiled fruit was removed from each test case. The results obtained from this study indicate the following:

1. Diphenyl phthalate appears to possess some fungicidal properties in so far as the preservation of oranges in corrugated fiberboard boxes is concerned. However, in the quantities and applications used in this study, it was inferior to Phenodor in which diphenyl is the active preservative. The results indicate that it is about intermediate between no preservative and Phenodor.

2. Within the range studied, the size of the particles or chips impregnated with diphenyl phthalate appears to have little influence on the holding qualities of oranges when used as disclosed in the Rinck patent.

3. In the tests with the impregnated particles or carrier material, there appears to be little difference in the holding qualities of liners or pads and small particles. Also, the position of the preservative within the cases does not appear to be critical, this is not surprising inasmuch as it works in the vapor state.

4. The results of the holding tests in which Phenodor-impregnated chips were packed with the fruit show that the amount of spoilage was less than exhibited by the fruit packed in the commercially treated Phenodor box.

5. As in the case of diphenyl phthalate, the size of the chips appears to have little influence on the amount of decay. The results using pads or liners were equivalent to those in which small size particles were used.

6. The results obtained with particles impregnated in different ways and to different degrees indicate that a two-sided impregnation of the carrier material is effective and most economical provided the surface density of the Phenodor does not exceed the critical level.

7. The use of carrier materials would appear to offer many advantages among which are:

A. A known amount of preservative can be added at the time of packing as chips can be stored in a gasproof container until ready for use.

B. Elimination of the Phenodor impregnating operation on boxes will undoubtedly raise the quality level of these boxes.

C. Orange cases can be warehoused without danger of losing so much Phenodor to render them unfit for shipment.

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INTRODUCTION

In co-operation with the Fourdrinier Kraft Board Institute, Inc., The Institute of Paper Chemistry initiated a series of holding tests using Florida and California oranges. This study was undertaken for the purpose of comparatively evaluating the efficiency of various Phenodor applications in preventing the decay of oranges packed in corrugated fiberboard cases. In particular, this investigation was concerned with the comparative holding qualities of the conventional Phenodor-treated orange cases (inside of box coated or impregnated with Phenodor) and the method of adding Phenodor as disclosed in U.S. patent 2,607,694 granted to A. J. Rinck, August 19, 1952, entitled, "Method for preventing decay of citrus fruits, vegetables, etc."

As disclosed in the patent, "this invention relates to improvement in methods and means to prevent formation of molds and decay of citrus fruits and vegetables. The primary object of this invention is the provision of an improved vehicle for supporting a mold inhibiting chemical in such a manner as to best provide for free circulation of the chemical vapor among packed citrus fruit.

"A further object of this invention is the provision of an inherent flexible but stiff absorbent card or paper, preferably of a

size smaller than the maximum dimension of the individual fruit with which it is to be packed, adapted to support a mold or spore-inhibiting chemical such as diphenyl...." The patent further anticipates the use of "masking agents" to nullify the odor of the diphenyl as may be seen from the following passage contained in the patent: "The stiff paper or card-like material is impregnated for at least part of its thickness with the chemical. The chemical supporting member may vary widely in nature, but is preferably fibrous and absorbent. It is to be noted that its size is such that at its greatest dimension it measures less than the maximum diameter of the vegetable or fruit with which it may be associated so as to fall freely into the voids between the packed fruit. The preferred mold-inhibiting chemical is diphenyl, and with it may be used volatile or deodorizing oils, etc....."

"Various changes in the shape, size and arrangement of the chemical carrying cards, and in the method of application thereto, may be made to the form of invention herein described without departing from the spirit of the invention or the scope of the claims....."

In addition to the above mentioned comparison, this study was designed to determine the effect of "chip" size as well as the relative effect of "surface density" of the impregnant on holding characteristics of oranges. The term chip as used herein refers to the chemical carrying material or particles as disclosed in the Rinck patent. The term surface density refers to the amount of impregnant per unit area of paperboard or chip surface wherein each side of the paperboard if impregnated, is considered as a separate surface. Further, for purposes

of comparison, holding tests were made with plain or untreated boxes as well as with impregnated pads or liners.

The relative efficiency of each Phenodor application was determined on the basis of the amount of decay. The oranges were stored at room temperature (for expediency) and 85 to 90% relative humidity. They were inspected each week for a period of four weeks and at each inspection the unsaleable oranges were removed from their respective cases.

Both California (220) and Florida (216) oranges were used. Also, two preservatives were used--diphenyl and diphenyl phthalate. Because of the unavailability of Florida oranges when this study was initiated, California oranges were used in the holding tests with the diphenyl phthalate and Florida oranges with diphenyl as the active preservative. The results obtained with these two preservatives are presented in Parts I and II, respectively.

PART I

As previously mentioned, this phase of the study is concerned with holding tests on California oranges (220) using diphenyl phthalate as the active preservative; however, the commercial orange cases used as a comparator were treated in the usual manner with Phenodor which utilizes diphenyl as the preservative.

MATERIALS USED & PROCEDURE

The fiberboard boxes used in these holding tests consisted of two lots of A-flute special-slotted containers, alike except that one lot had been commercially treated on the inside flaps and end panels with Phenodor (approximately 8 pounds per thousand square feet of a 50-50 mixture by weight of diphenyl and wax) and the boxes in the other lot remained untreated.

The carrier material or "chips" were prepared by impregnating a 30-pound grade of chipboard with a 50-50 mixture by weight of diphenyl phthalate and wax. The diphenyl phthalate-wax mixture was applied to both sides of the 30-lb. chipboard as a hot melt at 145°F. The pickup was 30.4%. After the chipboard had been impregnated as described above, it was cut into the desired sizes. These ranged from one inch squares to a pad equivalent to the cross sectional area of the box.

The oranges were purchased locally in wood crates. The total lot of oranges was made up from California packers namely:

Gold Banner from Gold Banner Association, Redlands, California

Renoun from Whittier Mutual Orange and Lemon Association, Whittier, California

Upland Pride from Euclid Avenue Orange Association, Uplands, California

Each case of oranges was carefully inspected and the good fruit packed in the fiberboard cases used in the holding tests so that each of the test cases received an equal number of oranges from each wood case received. The oranges were packed in four layers of 27 each except the top layer which contained 29. The number of cases, amount, and distribution of preservative used in this study are given in Table I.

TABLE I

PACKING ARRANGEMENT

Series	No. of Boxes Used	Treatment
1	5	Control--no treatment
2	5	Commercial Phenodor box
3	5	73 grams diphenyl phthalate-treated chips, 2.25-inch squares distributed uniformly among fruit
4	5	73 grams diphenyl phthalate-treated chips, 1-inch squares distributed uniformly among fruit
5	5	73 grams diphenyl phthalate-treated chips, 1.6-inch squares distributed uniformly among fruit
6	5	73 grams diphenyl phthalate-treated chipboard used as two pads (each 21 x 12 inches), one pad placed on top and one pad on bottom, each overlapping end of rows
7	5	73 grams diphenyl phthalate-treated chipboard used as folded pad placed between central layer of oranges

STORAGE CONDITIONS AND INSPECTION

After packing as shown in Table I, each case was sealed and then stored in an atmosphere maintained at 85 to 90% relative humidity and 73°F. for a period of four weeks. The abnormally high storage temperature was used as an expediency. At the end of each seven-day period, the cases were opened and the fruit examined for spoilage. After each inspection the spoiled fruit was removed from its respective case, the case was resealed, and then stored in the same atmosphere. In order to minimize variation in inspection as much as possible one inspector was used for all the evaluation work. Spoilage as used in this phase of the study included mold, stem rot, or shriveled and peel rot.

DISCUSSION OF RESULTS

The results of the holding tests conducted in this phase of the study are shown in Table II. It may be seen from the results given in this table that the oranges packed in the Phenodor-treated boxes exhibited the least spoilage and those packed with no preservative the most. Similarly, the Phenodor treatment appears to possess better fungicidal properties for oranges than does diphenyl phthalate, although the latter is an improvement over no preservative as was the case in Series 1. This is particularly significant inasmuch as more diphenyl phthalate was used per case than diphenyl in the Phenodor.

A comparison of the results obtained in Series 4 through 7 indicates that the size or position of the preservative had little effect on the holding characteristics of the oranges packed in the manner employed.

TABLE II

HOLDING TEST RESULTS

Series	Preservative	Carrier	No. Oranges per Case	Accumulative Spoilage* 1st Week No.	1st Week %**	2nd Week No.	2nd Week %**	3rd Week No.	3rd Week %**	4th Week No.	4th Week %**
1	None—control	—	102	17	15.5	24	21.8	30	27.3	46.2	42.0
2	Commercial Phenodor Box	—	102	7.6	6.9	10.4	9.5	16	14.5	32.0	29.1
3	Diphenyl phthalate	2.25 x 2.25-inch chips	102	11.0	10.0	17.2	15.6	24.4	22.2	37.8	34.4
4	Diphenyl phthalate	1 x 1-inch chips	102	10.6	9.6	15.0	13.6	21.6	19.6	40.0	36.4
5	Diphenyl phthalate	1.6 x 1.6-inch chips	102	13.0	11.8	18.6	16.9	23.2	21.1	42.4	38.5
6	Diphenyl phthalate	2 pads	102	9.2	8.4	13.8	12.5	20.6	18.5	37.8	34.4
7	Diphenyl phthalate	1 pad	102	9.4	8.5	15.4	14.4	21.4	19.6	39.6	36.0

* Average of the five test cases.
** Based on number of oranges packed in box.

PART II

As previously mentioned, this phase of the study is concerned with holding tests on Florida oranges (216) using diphenyl as the active preservative in all the holding tests made in this phase.

MATERIALS USED AND PROCEDURE

The fiberboard boxes used were from the same lots as described in Part I. The carrier materials or chips were prepared by impregnating a 30-pound grade of chipboard with Phenodor (a 50-50 mixture by weight of diphenyl and wax). The Phenodor was applied as a hot melt at 145°F. Unlike the procedure used in Part I, wherein all the carrier stock was impregnated from both sides with a fixed amount of preservative, different degrees of impregnation, from one and two sides, were used in this phase of the study. The purpose was to determine if the depth of impregnation (surface density) had an influence on the holding characteristics of oranges. For example, two samples of the 30-pound chipboard were impregnated with 8 pounds per thousand square feet of Phenodor. One was impregnated with 4 pounds on each side whereas the other was impregnated with 8 pounds from one side. Inasmuch as the diphenyl in the Phenodor is effective as a fungicidal material for oranges only in the vapor state, the rate of evaporation as well as concentration are critical factors. It is felt that the rate of evaporation of the diphenyl would be greater for the sample impregnated on two sides than for the sample impregnated on one side with the same amount of Phenodor. In the case of the former, the surface density would be half that of the latter and it follows that for the same amount of Phenodor, twice the surface area would be exposed.

The conventional Phenodor-treated case is impregnated with approximately 8 pounds of Phenodor per 1000 square feet. This gives a surface density (weight per unit surface area) of 3.712 grams of Phenodor or 1.86 grams of diphenyl per square foot of treated surface exposed. The carrier material was impregnated in a number of different ways (Table III) to give "chips" of different surface densities and sizes.

TABLE III

Series	Diphenyl-wax Content, %	Number of Sides Treated	Surface Density, g./sq. ft.
8	21	1	1.85
9	12	1	0.65
10	36	1	3.88
11	19.2	2	0.31
12	26.0	2	1.22
13	35.0	2	2.03

The carrier materials prepared as shown in Table III were cut into different size squares as well as pads or liners for packing with the fruit in the untreated boxes. In addition, oranges were packed in commercially treated Phenodor boxes as well as in untreated boxes. For purposes of comparison, one series of tests was conducted with oranges which had been subjected to diphenyl vapor for a 24-hour period prior to packing in untreated boxes in order to determine the holding characteristics of fruit so treated.

The oranges were Florida (216) obtained from a local dealer. They were received in wooden boxes and were packed by the Lakeland

Packing Company, Lakeland, Florida. All fruit was carefully inspected prior to being packed in the fiberboard test cases. The oranges were packed in the test cases in four layers of 27 each except for the top layer which contained 29.

The different applications of Phenodor used in this phase, together with the series number, may be seen in Table IV.

STORAGE CONDITIONS AND INSPECTION

After packing as shown in Table IV, each case was sealed with tape and then stored in an atmosphere maintained at 85 to 90% relative humidity and 73°F. for a period of twenty-one days. As was the case in Part I, the abnormally high storage temperature was used as an expediency. The cases were inspected on the eighth, sixteenth, and twenty-first day. On these days the cases were opened, inspected for spoilage, the spoiled fruit removed before resealing. In order to minimize variation in the inspection, the same inspector was used for all work. Oranges were considered spoiled if they contained: mold, stem rot, spotty decay, rot at calyx, or total decay.

DISCUSSION OF RESULTS

As previously mentioned, the holding tests made in this phase were for the purpose of comparing the merits of various applications of Phenodor on the holding characteristics of oranges packed in fiberboard boxes. These included storage tests on oranges packed in untreated boxes, commercially treated Phenodor boxes, and boxes in which chips or pads

TABLE IV

METHOD AND AMOUNT PHENODOR USED

Series	No. of Cases Tested	Carrier	Amount Carrier and Phenodor per Box, g.	Degree of Impregnation, %	No. of Sides Treated	Size Chip, in.	Total Board Used, sq.ft.	Surface Density, g./sq.ft.*	Position of Carrier Material
8-a	5	Pad	80.2	21	1	—	4.64	1.85	Lined top, bottom, and ends.
8-b	5	Chip	80.2	21	1	1 x 1	4.64	1.85	Half chip added when case half filled, balance on top.
8-c	5	Chip	80.2	21	1	1.6x1.6	4.64	1.85	Distributed uniformly throughout cases.
8-d	5	Chip	80.2	21	1	2.25x2.25	4.64	1.85	Distributed uniformly throughout cases.
9-a	5	Pad	140.3	12	1	—	9.28	0.65	Lined entire inside of box, impregnated side in.
9-b	5	Chip	140.3	12	1	1x1	9.28	0.65	Half in middle, balance on top.
10-a	5	Pad	46.8	36	1	—	2.32	3.88	Pad folded, impregnated side out, placed in center.
10-b	5	Chip	46.8	36	1	1x1	2.32	3.88	Half in middle, balance on top.
11-a	5	Pad	87.7	19.2	2	—	5.07	0.31	
11-b	5	Chip	87.7	19.2	2	1x1	5.07	0.31	
12-a	5	Pad	64.8	26.0	2	—	3.48	1.22	
12-b	5	Chip	64.8	26.0	2	1x1	3.48	1.22	
13-a	5	Pad	48.2	34.9	2	—	2.32	2.03	
13-b	5	Chip	48.2	34.9	2	1x1	2.32	2.03	
14	5	Vapor treated	—	—	—				
15	5	Commercial Phenodor Box	—	**				**	
16	5	No treatment	—						

* On two-side treatment, total area equals sum of area of each side.
** Normal treatment—8 pounds per 1000 sq. ft. or surface density of 1.86 g./sq. ft.

impregnated with Phenodor were inserted between or around the fruit. In addition, oranges which had previously been subjected to vapors of diphenyl were packed in untreated cases.

The results of the holding tests on oranges made in this phase are given in Table V. It may be seen from the data in Table V that the amount of decay for oranges packed according to the method disclosed in the Rinck patent was in most cases less than when packed in commercial Phenodor boxes. The greatest amount of decay was observed in the oranges which had been gassed with diphenyl and those which received no treatment.

The effect of the size of the impregnated particles may be seen from a comparison of the data in Table VI. It may be noted that, on the basis of these results, the size of the impregnated particle or chip has little if any influence on the amount of decay. In addition, the test cases using the impregnated particles or chips exhibited less spoilage than was obtained with the commercial Phenodor boxes. In this particular series the carrier material was impregnated from one side and the amount of Phenodor was held constant to give the same surface density as was used on the commercial Phenodor. Thus, these results appear to indicate that the impregnated particles or chips impart a greater fungicidal atmosphere than does the commercial Phenodor-treated box. This is not to be wondered at inasmuch as the commercial box may have lost some of its diphenyl (due to evaporation) between the time this box was impregnated and the time the oranges were packed. This is one disadvantage of the commercial Phenodor-treated boxes. The chips on the other hand can be stored in gasproof containers, thereby being at full strength when added to the orange case.

TABLE V

SUMMARY OF HOLDING TEST RESULTS
(85-90% R.H. and 73°F.)

Series	Carrier	Weight Carrier & Phenodor Used, g.	Degree of Impregnation, %	No. of Sides Treated	Size Chip, in.	Total Board Used, sq. ft.	Surface Density of Phenodor, g./sq. ft.	Decay, %** 8 days	16 days	21 days
8-a	Pad	80.2	21	1	—	4.64	1.85	14.5	21.6	33.0
8-b	Chip	80.2	21	1	1 x 1	4.64	1.85	14.5	21.6	31.3
8-c	Chip	80.2	21	1	1.6 x 1.6	4.64	1.85	17.9	23.1	31.0
8-d	Chip	80.2	21	1	2.25 x 2.25	4.64	1.85	15.7	20.1	28.4
9-a	Pad	140.3	12	1	—	9.28	0.65	12.3	19.1	30.2
9-b	Chip	140.3	12	1	1 x 1	9.28	0.65	13.0	21.0	33.0
10-a	Pad	46.8	36	1	—	2.32	3.88	21.9	34.3	46.3
10-b	Chip	46.8	36	1	1 x 1	2.32	3.88	22.5	29.3	41.3
11-a	Pad	87.7	19.2	2	—	5.07	0.31	17.9	29.6	45.7
11-b	Chip	87.7	19.2	2	1 x 1	5.07	0.31	23.8	32.1	43.2
12-a	Pad	64.8	26.0	2	—	3.48	1.22	19.8	25.3	33.3
12-b	Chip	64.8	26.0	2	1 x 1	3.48	1.22	20.1	28.4	37.3
13-a	Pad	48.2	34.9	2	—	2.32	2.03	14.2	22.8	33.0
13-b	Chip	48.2	34.9	2	1 x 1	2.32	2.03	13.3	24.4	34.6
14	Vapor treated*	—	—	—	—	—	—	26.2	60.5	72.8
15	Phenodor box	—	—	—	—	—	—	19.8	30.9	41.0
16	No treatment	—	—	—	—	—	—	39.2	60.5	67.2

* Oranges exposed to vapors from 2.786 g. diphenyl per case which was vaporized over a 24-hour period.

** Based on number of oranges packed per case.

TABLE VI

COMPARISON OF CARRIER OF CHIP SIZE ON HOLDING QUALITIES
(85-90% R.H. and 73°F.)

Series	Carrier	Weight Carrier & Phenodor Used, g.	Degree of Impregnation, %	No. of Sides Treated	Size Chip, in.	Total Board Used, sq. ft.	Surface Density of Phenodor, g./sq. ft.	Decay, %* 8 days	16 days	21 days
8-a	Pad	80.2	21	1	—	4.64	1.85	14.5	21.6	33.0
8-b	Chips	80.2	21	1	1 x 1	4.64	1.85	14.5	21.6	31.3
8-c	Chips	80.2	21	1	1.6 x 1.6	4.64	1.85	17.9	23.1	31.0
8-d	Chips	80.2	21	1	2.25 x 2.25	4.64	1.85	15.7	20.1	28.4
15	Commercial Phenodor	—	—	—	—	4.64	1.86	19.8	30.9	41.0
16	No treatment	—	—	—	—	—	—	39.2	60.5	67.2

* Based on number of oranges packed per case.

Table VII gives a comparison of the effect of the degree of impregnation on the holding qualities of the various packs. The purpose of this phase was to determine if there was a point of diminishing returns. For example, the extreme would be simply to add a pellet of Phenodor equivalent to the total Phenodor content of the commercial Phenodor-treated box. Under such conditions, it would be anticipated that the quantity of diphenyl evaporated per unit time would be insufficient to preserve the oranges. The other extreme would be to add the same amount of diphenyl lightly impregnated (low surface density) on one side of the carrier material. The latter condition would permit the diphenyl to evaporate more readily because of the greater surface. This would probably be the more effective way of adding diphenyl as a preservative in the storage and shipment of oranges. However, the greater area would involve more chipboard and consequently, the cost of the carrier material would increase proportionately. As previously mentioned, the total amount of Phenodor used was the same in all test cases--only the depth of impregnation and the area of treated surface exposed varied.

It may be seen from the data presented in Table VII that the results obtained on one square inch area chips, impregnated from one side only, show that when the surface density of Phenodor is in the neighborhood of 3.88 g./sq. ft., the amount of diphenyl available in the vapor state is insufficient for maximum preservation as compared to the results obtained with surface densities of 0.65 and 1.85. It would appear that for one-side application, the critical density level is between 1.85 and 3.88. There appears to be no significant difference in the results at

TABLE VII

EFFECT OF SURFACE DENSITY OF PHENODOR ON HOLDING QUALITIES
(85-90% R.H. and 73°F.)

Series	Carrier	Weight Carrier & Phenodor Used, g.	Degree of Impregnation, %	No. of Sides Treated	Size Chip, in.	Total Board Used, sq. ft.	Surface Density of Phenodor, g./sq. ft.	Decay, %** 8 days	16 days	21 days
					Chips					
9-b	Chip	140.3	12	1	1 x 1	9.28	0.65	13.0	21.0	33.0
8-b	Chip	80.2	21	1	1 x 1	4.64	1.85	14.5	21.6	31.3
10-b	Chip	46.8	36	1	1 x 1	2.32	3.88	22.5	29.3	41.3
11-b	Chip	87.7	19.2	2	1 x 1	5.07	0.31	23.8	32.1	43.2
12-b	Chip	64.8	26.0	2	1 x 1	3.48	1.22	19.8	25.3	33.3
13-b	Chip	48.2	34.9	2	1 x 1	2.32	2.03	14.2	22.8	33.0
15	Commercial Phenodor box		*			4.64	*	19.8	30.9	41.0
16	No treatment		0	—	—	—	—	39.2	60.5	67.2
					Pads					
9-a	Pad		12	1		9.28	0.65	12.3	19.1	30.2
8-a	Pad		21	1		4.64	1.85	14.5	21.6	33.0
10-a	Pad		36	1		2.32	3.88	21.9	34.3	46.3
11-a	Pad		19.2	2		5.07	0.31	17.9	29.6	45.7
12-a	Pad		26.0	2		3.48	1.22	19.8	25.3	33.3
13-a	Pad		34.9	2		2.32	2.03	14.2	22.8	33.0
15	Commercial Phenodor box		*	—		4.64	*	19.8	30.9	41.0
16	No treatment		—	—		—	—	39.2	60.5	67.2

* Normal specification calls for approximately 21% impregnation which gives a surface density of approximately 1.86 g./sq. ft. of treated surface.

** Based on number oranges packed per case.

the two lower surface densities. The results obtained using pads parallel or confirm those obtained with the one-side impregnated chips.

As pointed out previously, if the preservative could be impregnated from both sides of the carrier material without impairing the holding quality of oranges packed with chips so treated, there would be considerable economy in so doing inasmuch as only half the amount of carrier material would be needed. The results given in Table VII for the oranges packed in boxes containing the two-sided impregnated chips indicate that, with the exception of Series No. 11-a and 11-b, the holding quality of the oranges with the chips impregnated from two sides was about the same as that obtained with the chips impregnated from only one side. Further, the results indicate that the critical surface density on 9-point 30-pound chipboard impregnated evenly from two sides is greater than 2.03 g. per square foot. Therefore, these results indicate that the application of Phenodor, the method of the Rinck patent, will provide means for preserving oranges packed in fiberboard boxes equal to or better than the commercially available Phenodor-treated box. Applying the preservative should have one very definite advantage in that a known amount of preservative can be applied at the time of packing as contrasted with the current Phenodor box which is subject to variations as a result of evaporation in storage as well as those resulting from nonuniformity of impregnation.

In the interest of economy it is suggested that an additional study be made in order to ascertain the maximum degree of impregnation (surface density) and therefore, the minimum amount of carrier material necessary to impart the desired fungicidal strength which will give equivalent holding qualities.